NOAA FISHERIES SERVICE

SWFSC

California Central Valley Survival Studies

(Section 5.1 Sacramento Survival Studies)

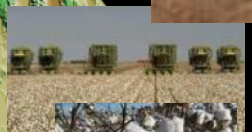
SWFSC, WCRO, NWFSC, UCSC, UC Davis, UW-SAFS, USFWS, USBR, USGS, Cramer Fish Sciences, CA DWR, CA DFW

Sean Hayes

Cinco de Mayo, 2015


?


CONGRESS CREATED
DUST BOWL




HOLLYWOOD


California
Aquaducts
Shasta Lake
Oroville Dam
Folsom Dam
Lake Tahoe
Sacramento
San Francisco
Mokelumne Aqueduct
Hetch-Hetchy Aqueduct
Mono Lake
Madera Canal
Friant Dam
Fresno
Owens Lake
Coastal Aqueduct
California Aqueduct
Friant Kern Canal
Los Angeles Aqueduct
Lake Mead
Hoover Dam
Lake Havasu
Parker Dam
Pacific Ocean
Los Angeles
Colorado River Aqueduct
San Diego Aqueduct
Salton Sea
Coachella Canal
All American Canal
Imperial Dam
San Diego
N
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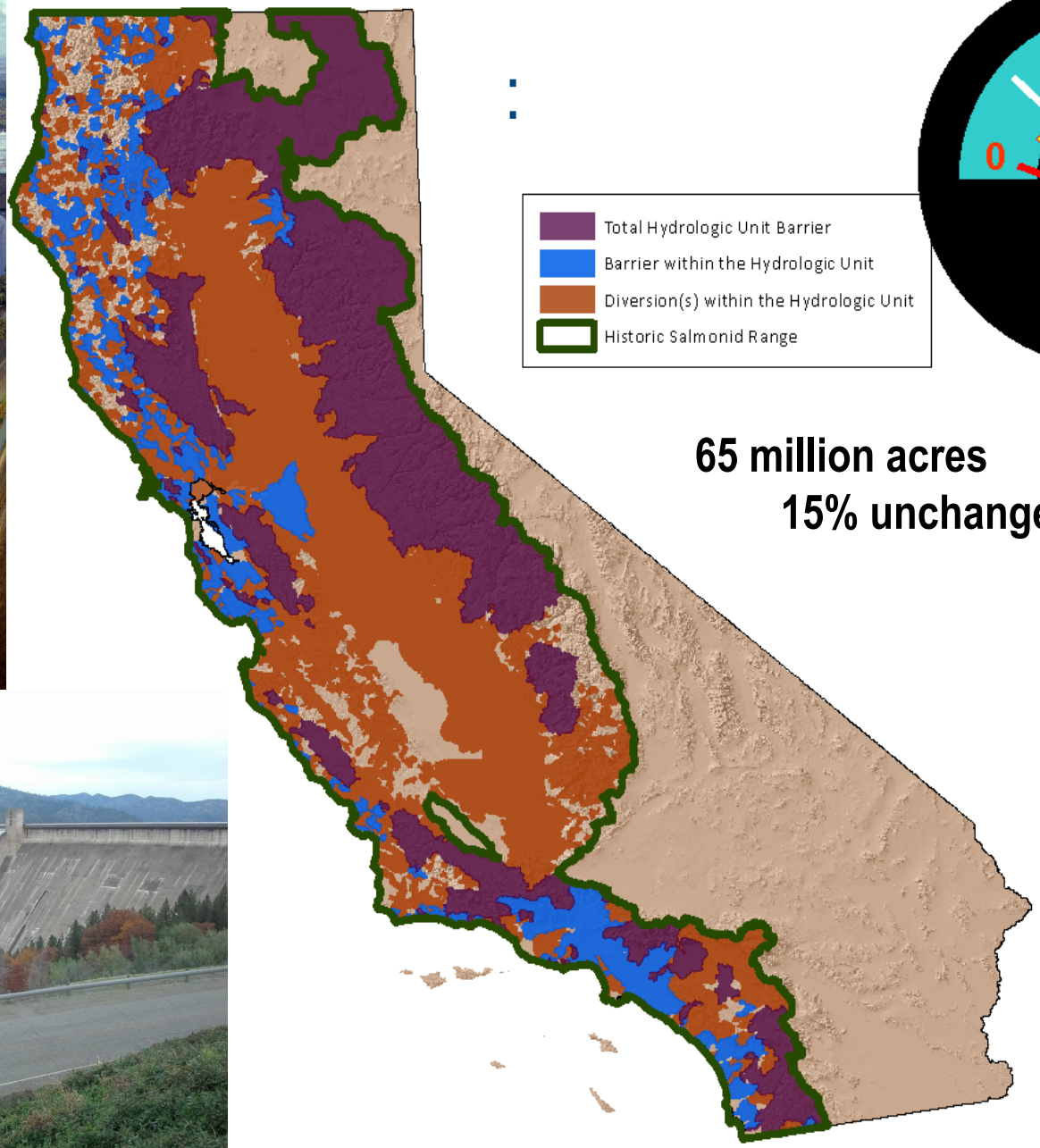
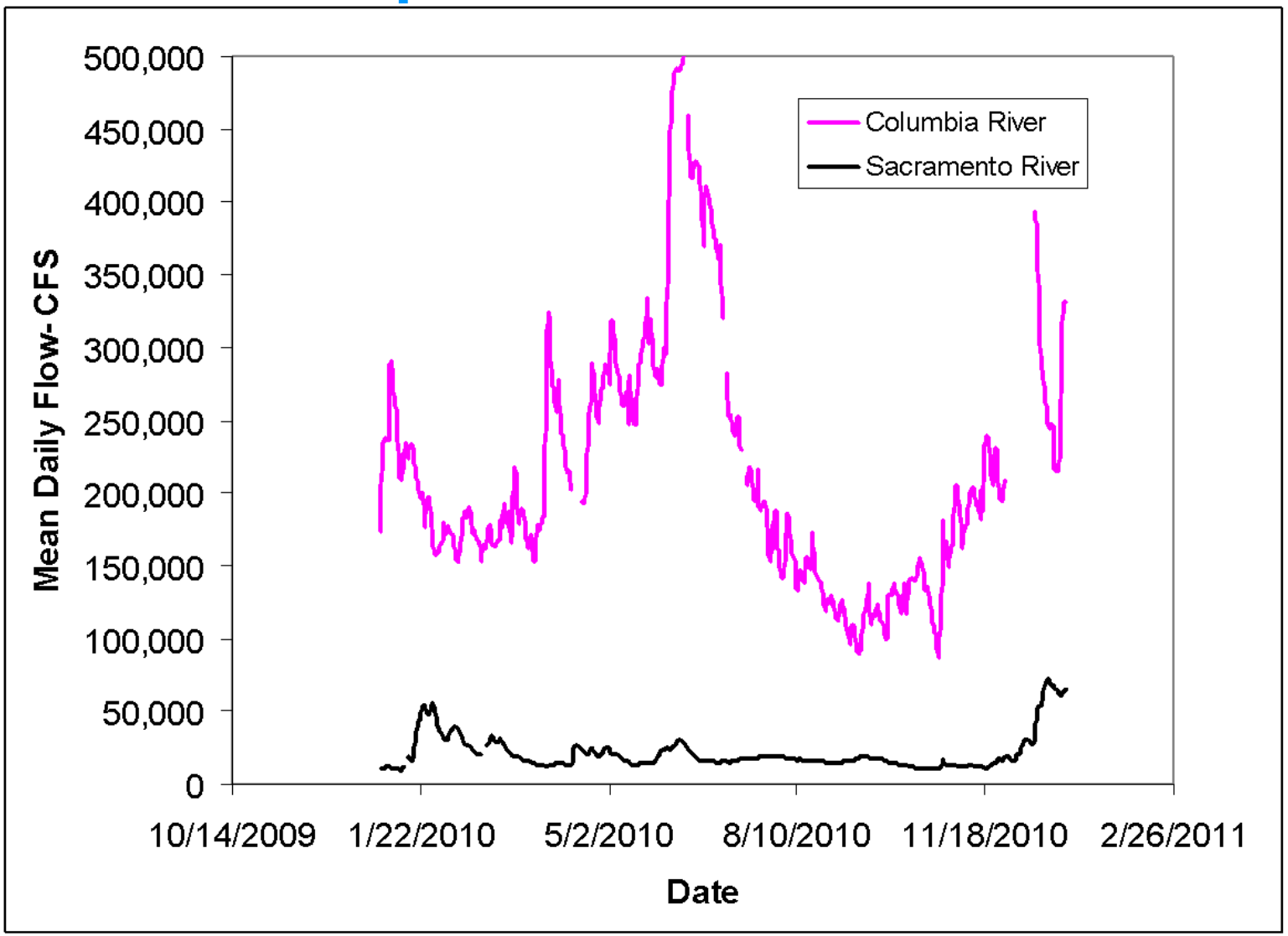


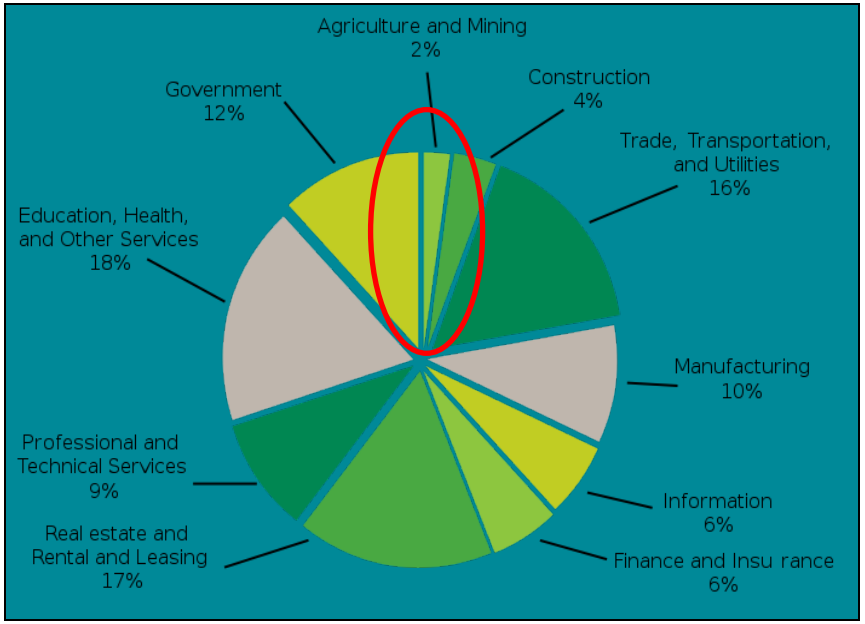
65 million acres

15% unchanged…..

River flow comparisons



California….. a $1.85 Trillion economy



Resource competition:

- 37 million people
- Introduced fisheries
- Mediterranean climate
- Industry prioritizes water diversion
- Ag industry worth $40+ Billion
  - (uses >80% of the water)

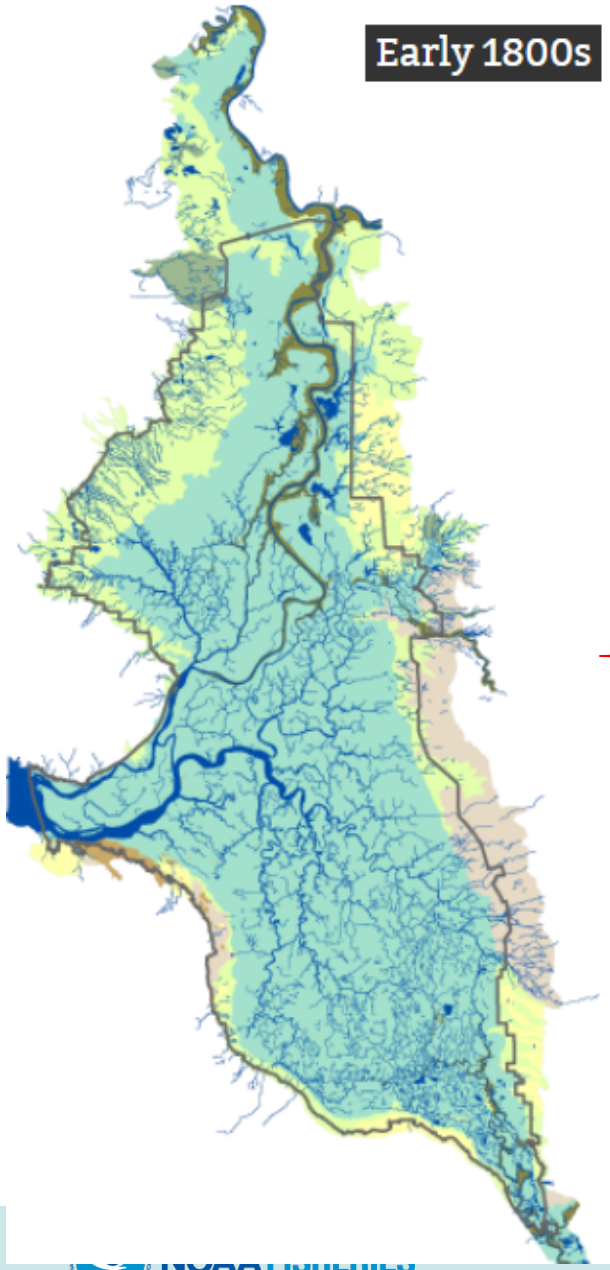
CALIFORNIA
Agricultural Statistics
2012 Crop Year

Crop and Livestock Commodities in which California Leads the Nation 1/

Almonds
Apricots
Artichokes
Asparagus
Avocados
Beans, Dry Lima
Beans, F.M. Snap
Bedding/Garden Plants
Broccoli
Brussels Sprouts
Cabbage, Chinese
Cabbage, F.M.
Carrots
Cauliflower
Celery
Chicory
Cotton, American Pima
Daikon
Dates
Eggplant
Escarole/Endive
Figs
Flowers, Bulbs
Flowers, Cut
Flowers, Potted Plants
Garlic
Grapes, Raisins
Grapes, Table
Grapes, Wine
Greens, Mustard
Hay, Alfalfa
Herbs
Kale
Kiwifruit
Kumquats
Lemons
Lettuce, Head
Lettuce, Leaf
Lettuce, Romaine
Limes
Mandarins & Mandarin Hybrids 2/
Melons, Cantaloupe
Melons, Honeydew
Milk
Milk Goats
Nectarines
Nursery, Bedding Plants
Nursery Crops
Olives
Onions, Dry
Onions, Green
Parsley
Peaches, Clingstone
Peaches, Freestone
Pears, Bartlett
Peppers, Chile
Peppers, Bell
Persimmons
Pigeons and Squabs
Pistachios
Plums
Plums, Dried
Pluots
Pomegranates
Raspberries
Rice, Sweet
Safflower
Seed, Alfalfa
Seed, Bermuda Grass
Seed, Ladino Clover
Seed, Vegetable and Flowe
Spinach
Strawberries
Tomatoes, F.M.
Tomatoes, Processing
Vegetables, Greenhouse
Vegetables, Oriental
Walnuts
Wild Rice

1/ California is the sole producer (99 percent or more) of the commodities in **bold**.

http://science.kqed.org/quest/delta-map/



Compare the Delta Across Eras

Click on the habitat types below to see how the Delta's waterways and landscape have been changed.

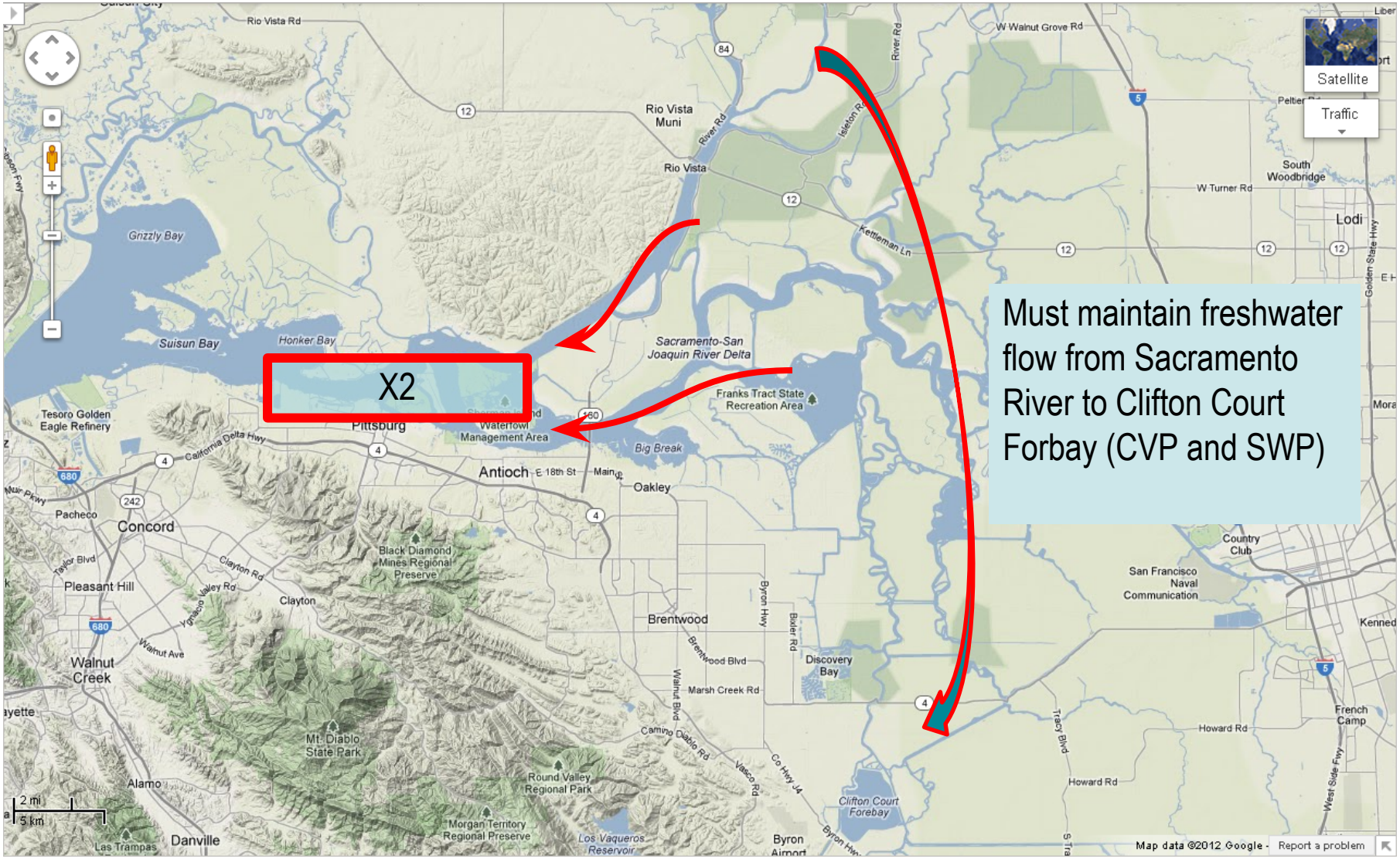
- Show All
- Agriculture
- Urban
- Water
- Freshwater Wetland
- Willow Thicket
- Riparian Forest
- Seasonal Wetland
- Dune Scrub
- Grassland
- Oak Woodland

Note:
The outline on the map at left indicates the mutually mapped area. The outline on the map at right indicates the boundary of the SFEI-ASC study.

Magnitude of Reclamation in the Sacramento-San Joaquin Delta, CA, 1860–1930

Decade	Hectares Reclaimed	Cumulative Hectares
1860-1870	6,070	6,070
1870-1880	37,231	43,301
1880-1890	28,328	71,629
1890-1900	23,472	95,101
1900-1910	35,612	130,713
1910-1920	38,040	168,753
1920-1930	9,712	178,465

Source: Thompson 1957



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SUBSIDENCE

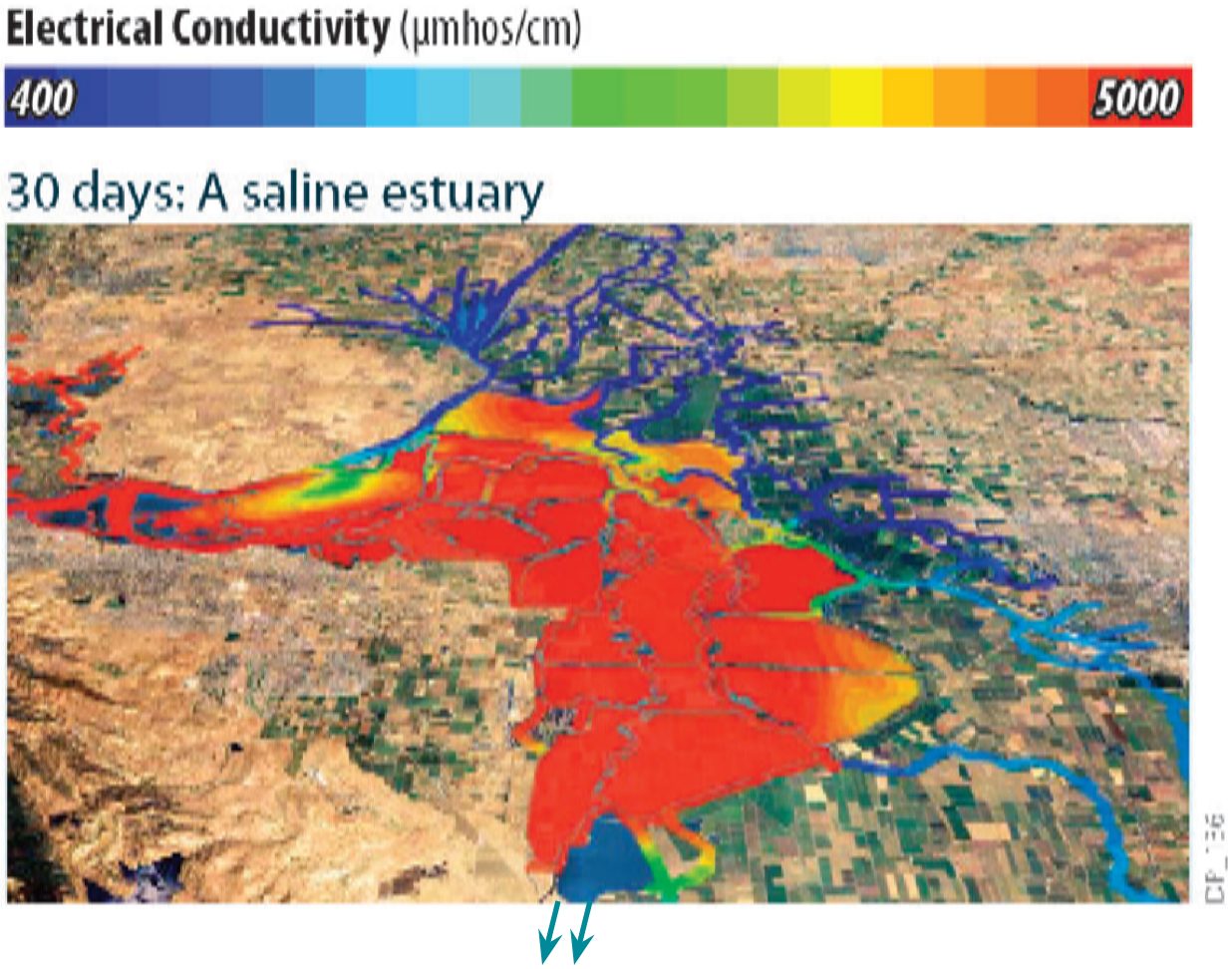
The Delta

- 1100 km of River Channel
- 1800 km of levees
- earth and stone 3-15m+ high
- 2000 km^2 land below 3-9m <sea level

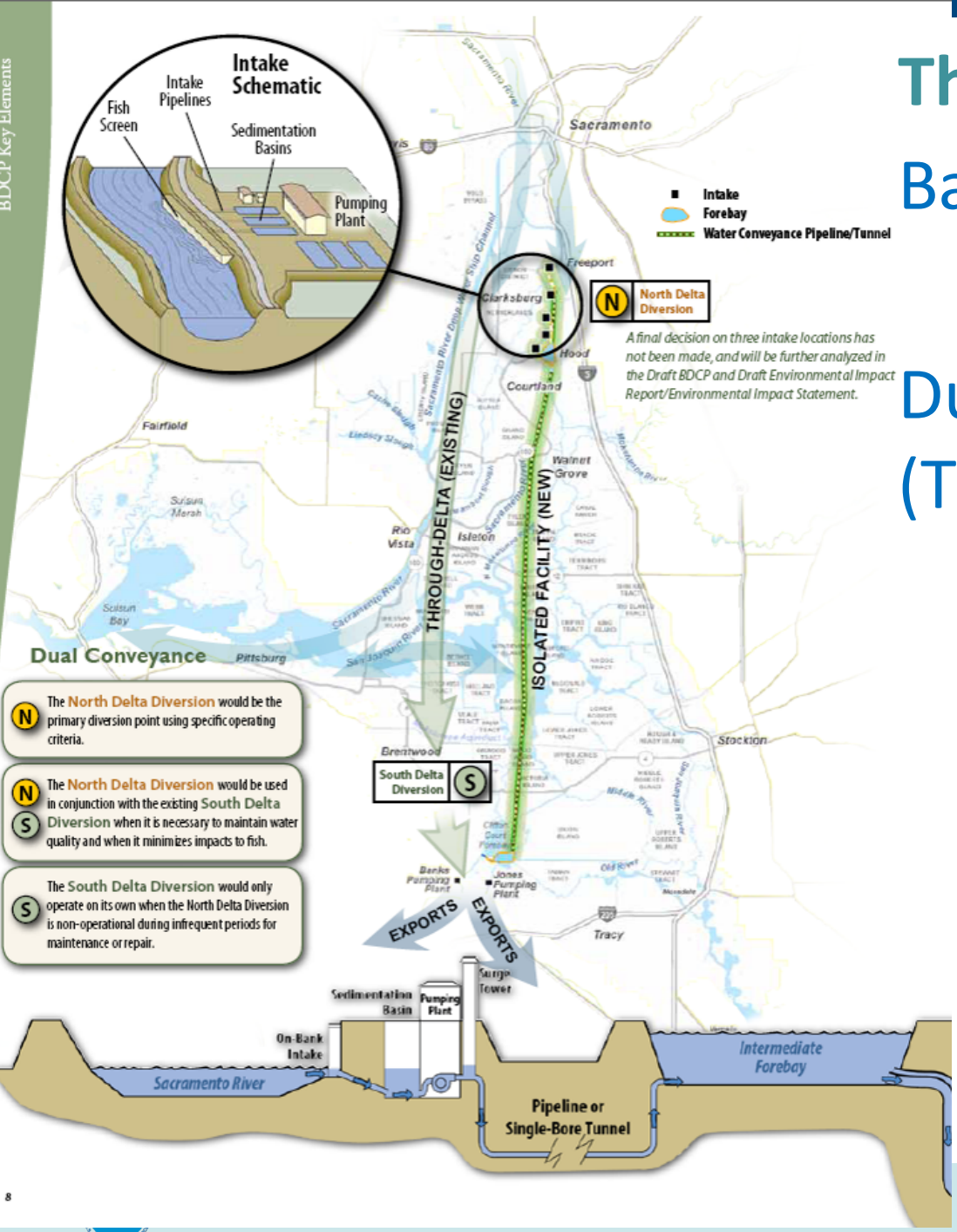
Sensitivity to Storms and Earthquakes?

Earthquake simulation (only a 6.5)

….a **62 percent** probability of occurring sometime between 2003 and 2032….(DWR 2009)



Southern California….



The Solution?

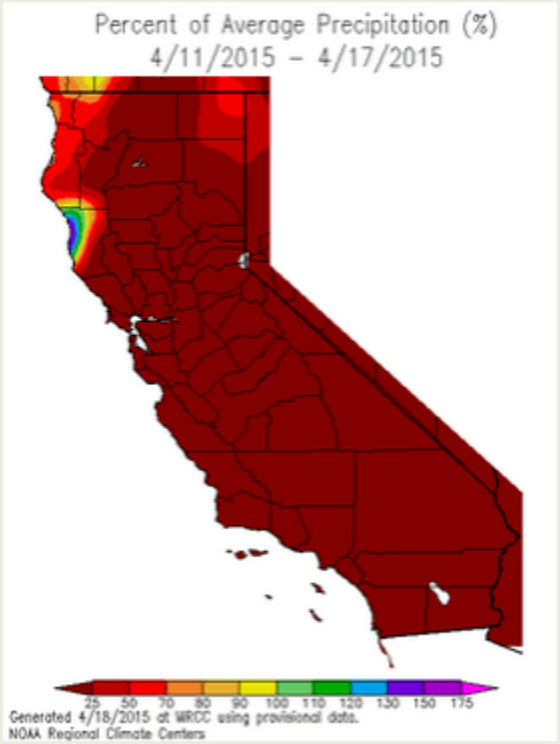
Bay Delta Cons. Plan -

Dual Conveyance (Tunnels)

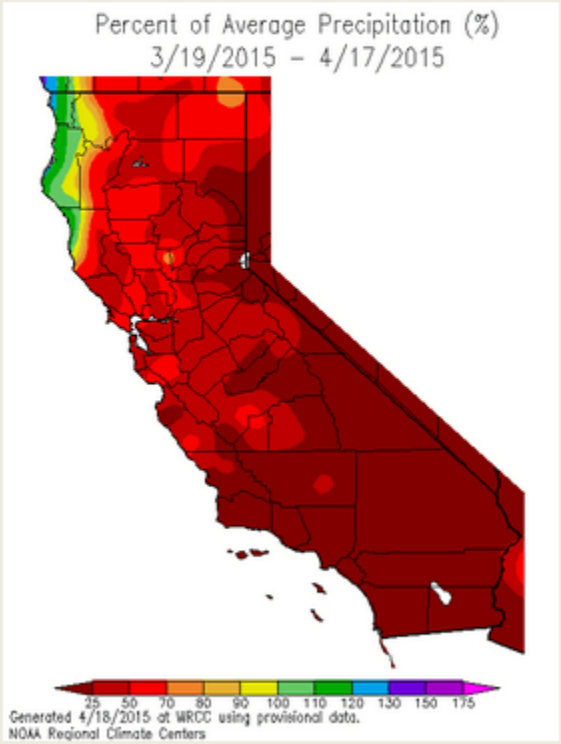
- 2 diversions= 6000 CFS
- $20 Billion+ project
- Concern to juvenile salmonids?
- Ya think?

Drought? (storage issue)

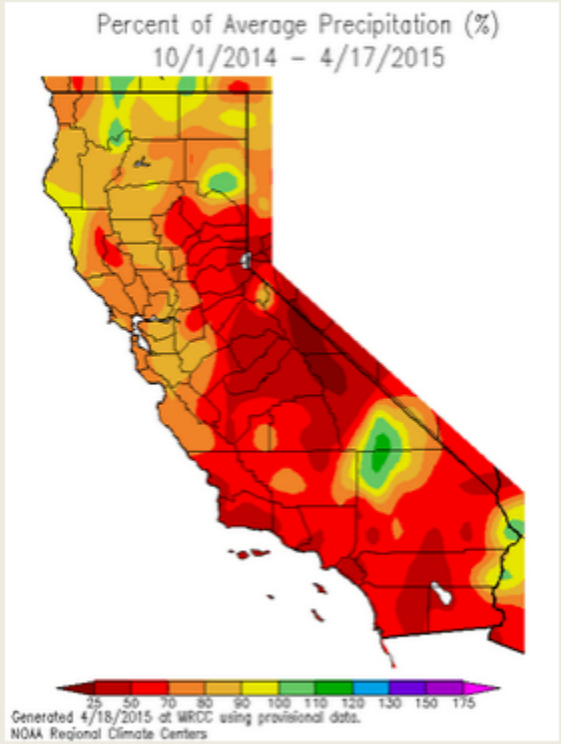
Last 7 Days % of Average Precipitation



Last 30 Days % of Average Precipitation



Oct 1 to Date % of Average Precipitation



Why is this a NMFS problem?

The Endangered Species Act

- Chinook Salmon
- Steelhead

The Blame….

- Fisherman?
- Predators?
- Water use?

Ambiguity= Inaction

Risks of Inaction

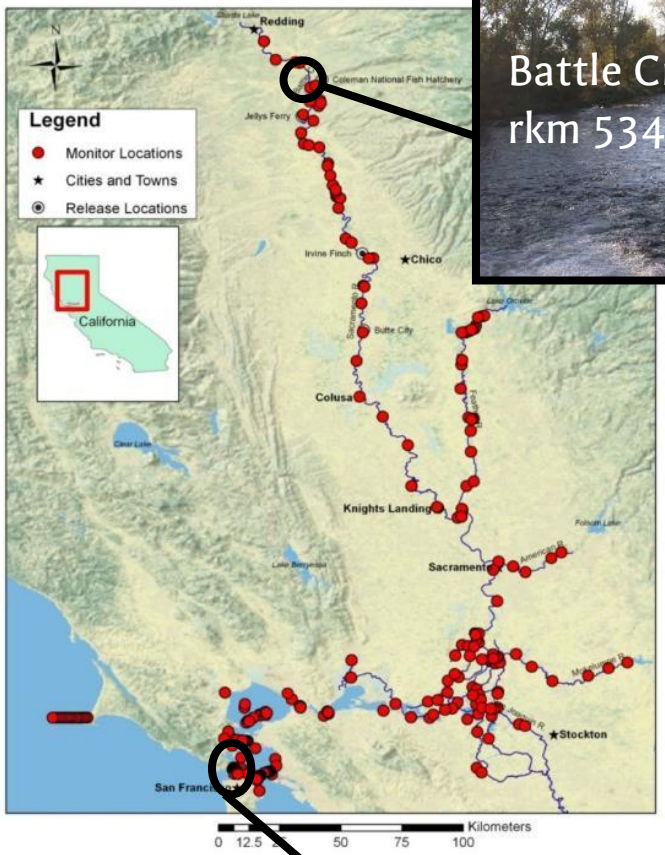
- ~$250,000,000 salmon economy
- Flood safety and livelihood for 500,000 people
- $40,000,000,000 agriculture
- Fresh water supply for 25,000,000 people

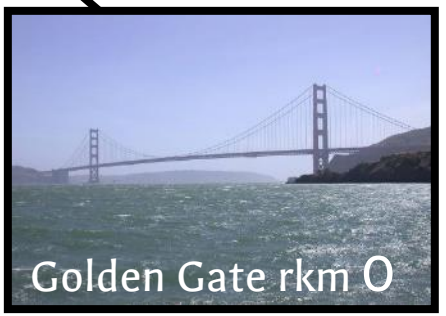
Any solution requires approval by NMFS

Need more data…..

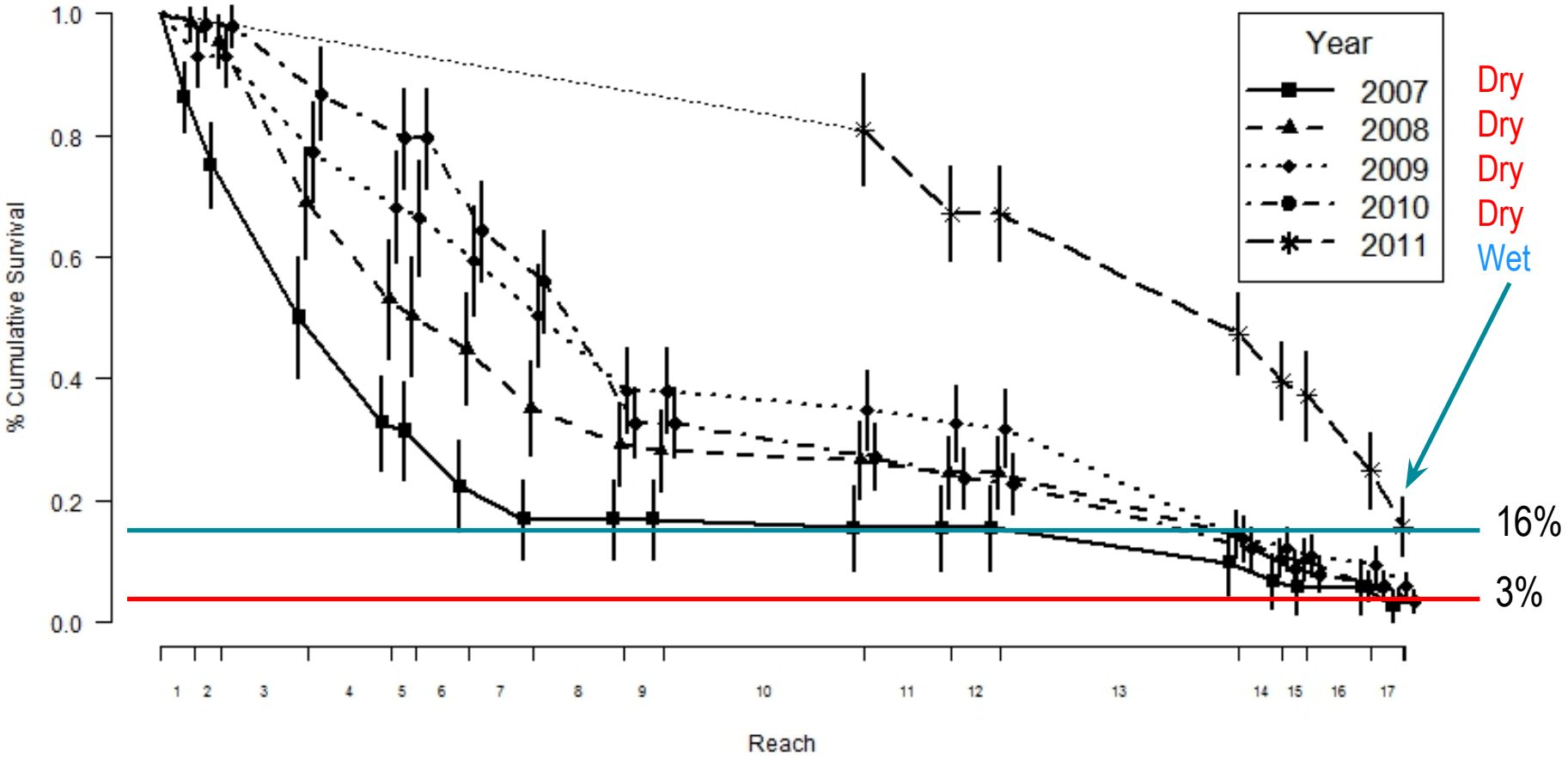
Empirical studies

- Juvenile outmigration survival
- Predation studies
  - Impact of water diversion
  - Habitat-Density interactions
- Integrated Life Cycle Modeling Efforts





Late Fall Chinook Survival to Golden Gate 2007-2011 (5 years)

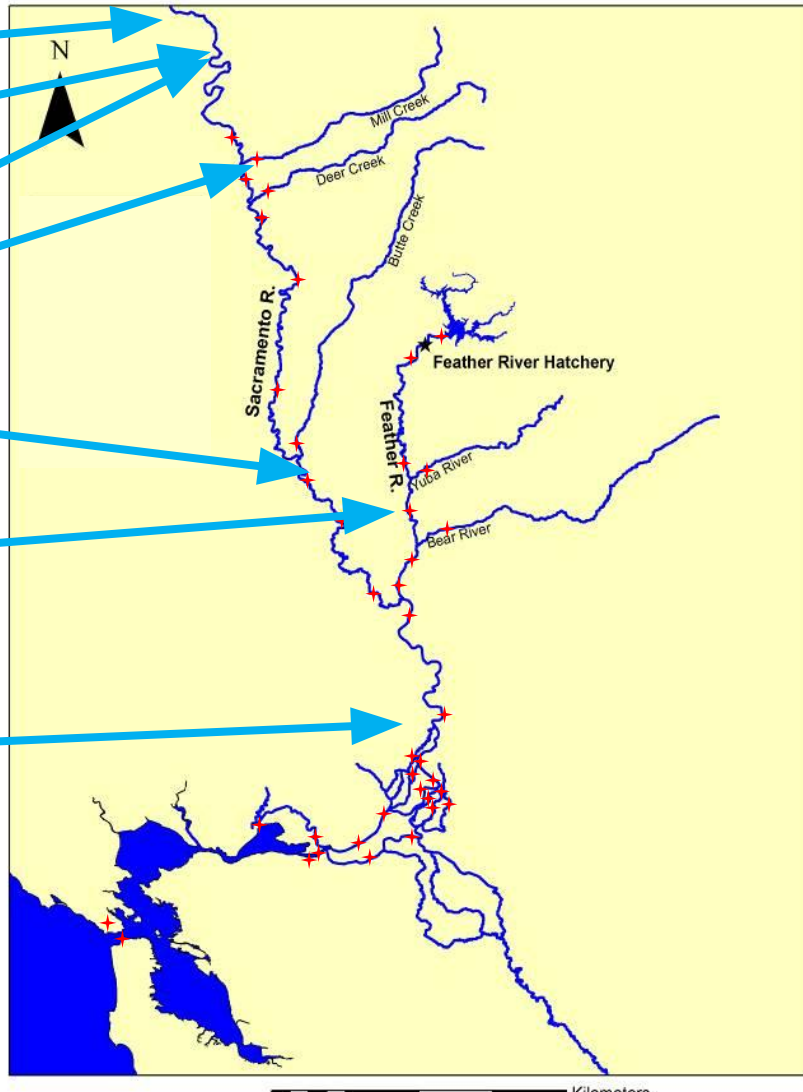


- Most effective life history strategy- SWIM FAST, get the hell out…
- This 84-97% mortality occurs in 2-3 weeks post hatchery release
- More water appears to = More fish…

Tagging Schedule 2012-2015

Tagging goals

- Winter run- LSNFS
  - 200-400 Jan
- Fall run- CNFH
  - 150 x 2 early/late Apr
- **Wild** tagging Spring and Fall
  - Mill, Battle, Butte-Sutter
  - 200-400 Nov-May
- Spring run from FRFH
  - 150 x2 Apr- upper/lower river
- Fall and Spring run releases into Delta
  - 100 f/100s x2 (repeat Perry et al 2010)

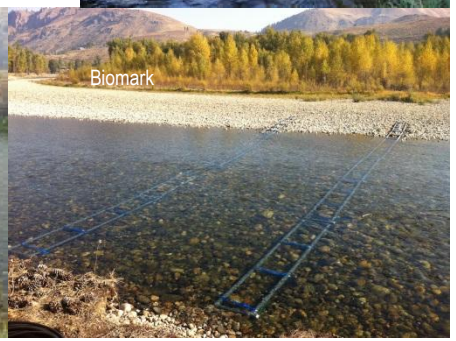


Comparative stock results

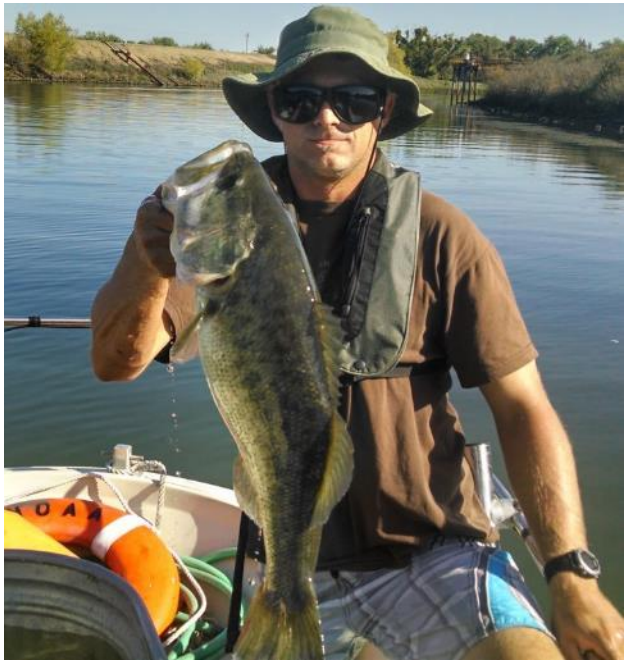
Run	Years	Survival	Transit time (days)	Area of Peak Mortality
Late Fall	2007-2011	3-16%	15-28	SF Bay
Fall	2012-2013	3-5%	8-17	SF Bay
Spring	2012-2015	0-3%	9-17	Feather River
Winter	2013-2015	4%	<20-54	Middle Sac
Wild Fall/Spring	2013-2014	0-1.4%	~10-20	Tributaries and Middle Sac

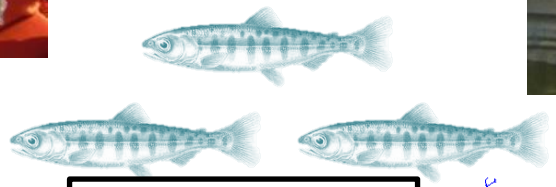
What about PIT tags?

- Two year feasibility study (2015-16)
- NOAA (SWFSC and NWFSC), USBR and CA DFW
- Deploy existing small-channel antennas a
- Engineer and deploy prototype large-channel detection arrays at two locations
- Develop/test boat -trawl antennas in the estuary
- Tag and release juvenile salmonids to estimate detection efficiency
- Identify additional sites



Mortality Causes?





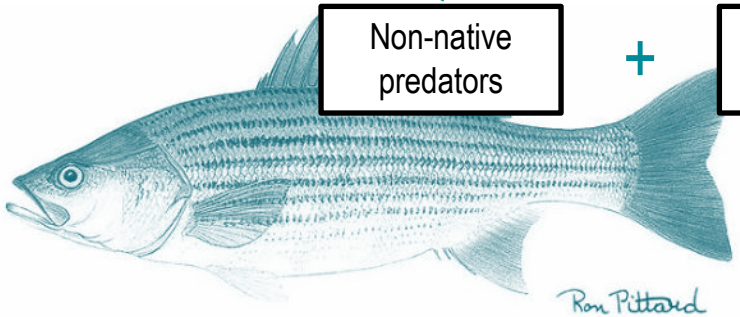
ESA-listed salmon and steelhead

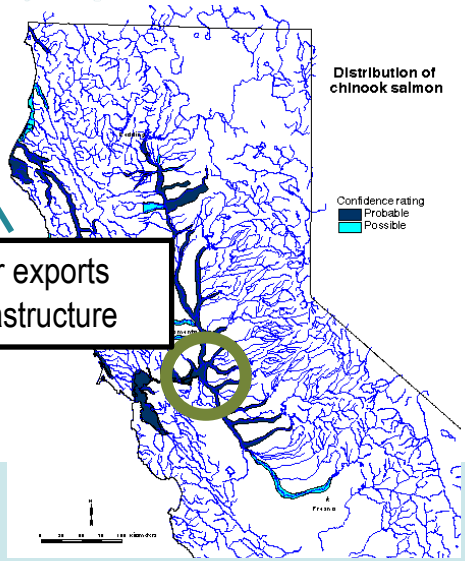
?

Non-native predators

+

Water exports & infrastructure





Bass present for 130+ years, why a problem now?

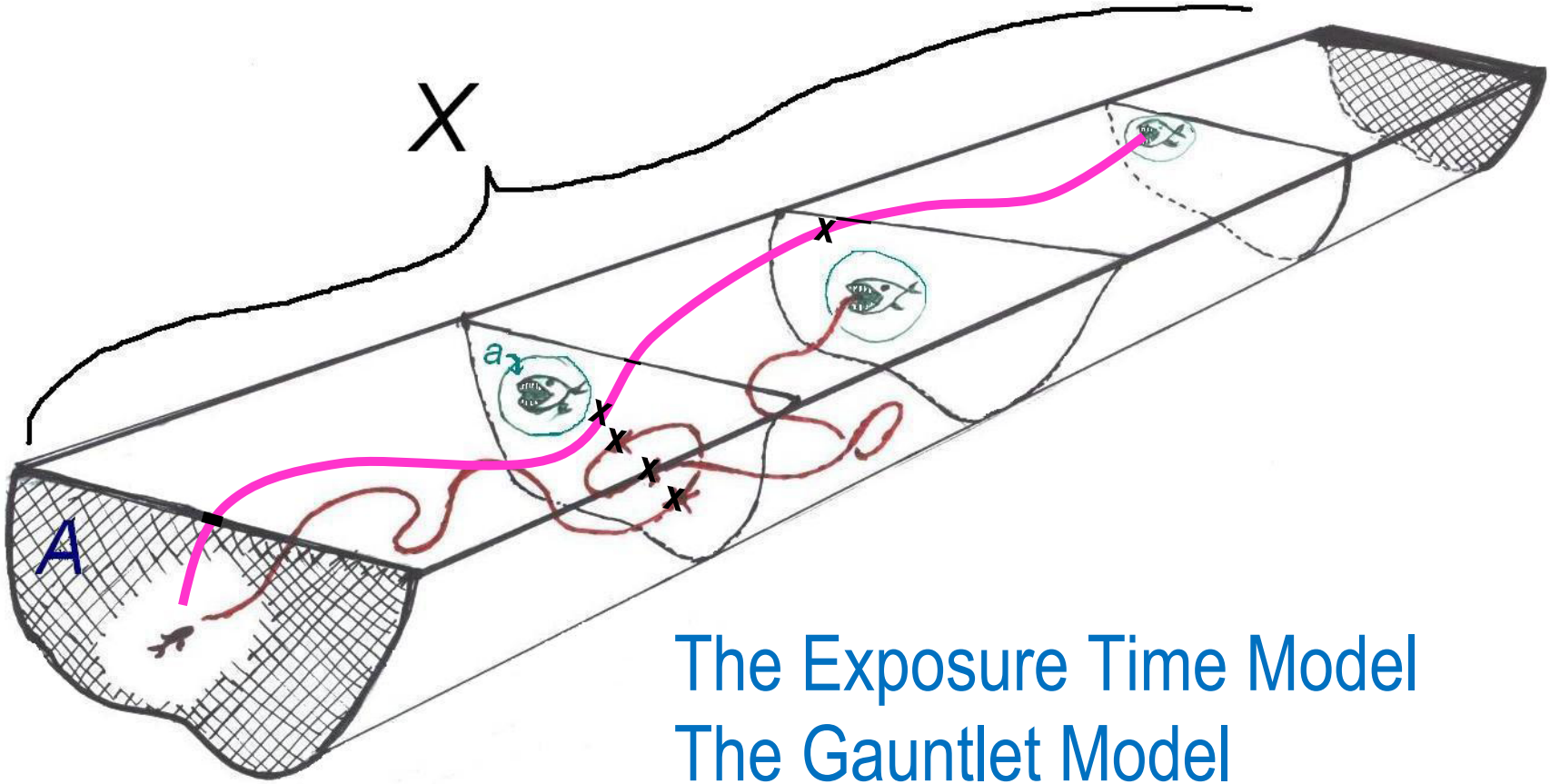
- Constant introductions of Invasive Species
  - Asian Clams
    - ***Corbicula fluminea***
    - ***Potamocorbula amurensis,***

  - Aquatic Plants
    - ***Egeria densa***

    - **Water Hyacinth**

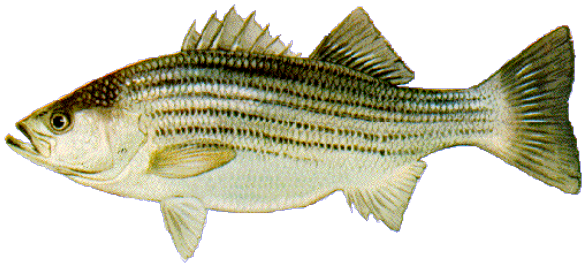
The XT Model Cartoon

Gurarie (2008) Anderson et al. (2005)



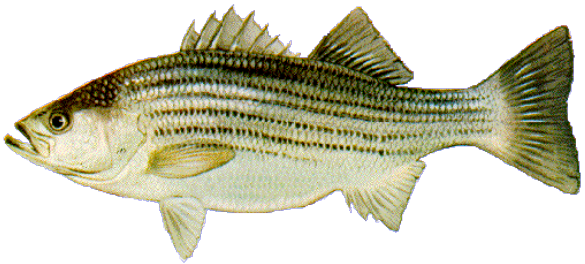
The Exposure Time Model
The Gauntlet Model

Effect of habitat on predation rate?



Diet in lower river = 80% crayfish, 0 salmon

- Habitat alterations matter!



+

Diet at Dam = 80% salmon

The Predator Issue….. Just how bad is it?

Loboschefsky, E., Benigno, G., Sommer, T., Rose, K., Ginn, T., Massoudieh, A., and Loge, F. 2012. Individual-level and Population-level Historical Prey Demand of San Francisco Estuary Striped Bass Using a Bioenergetics Model. San Francisco Estuary and Watershed Science **10**(1).

- Sacramento Bay/Delta populations of striped bass consume….

  ~25,000,000 kg of fish per year

All CV juv salmon

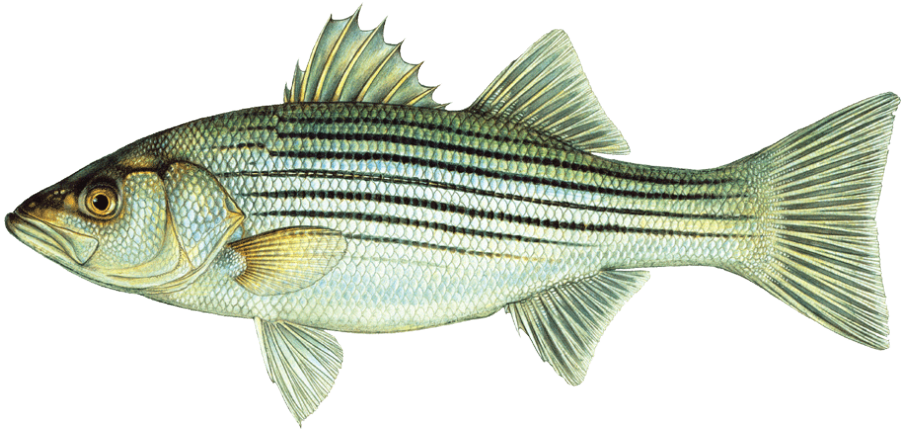
~240,000 kg

~1% of bass diet?

Delta Predation Studies

- ***Objective 1*** - Determine representative **densities and local spatial distributions of predator fish**
- ***Objective 2*** - Quantify the magnitude of predation through **genetic analysis of predator stomach contents**
- ***Objective 3*** - Conduct a controlled large-scale **experiment that manipulates the density of predators**
- ***Objective 4*** - Determine how predation on salmon smolts may be influenced by **physical habitat, water chemistry, and other environmental features**

Predators



Striped bass

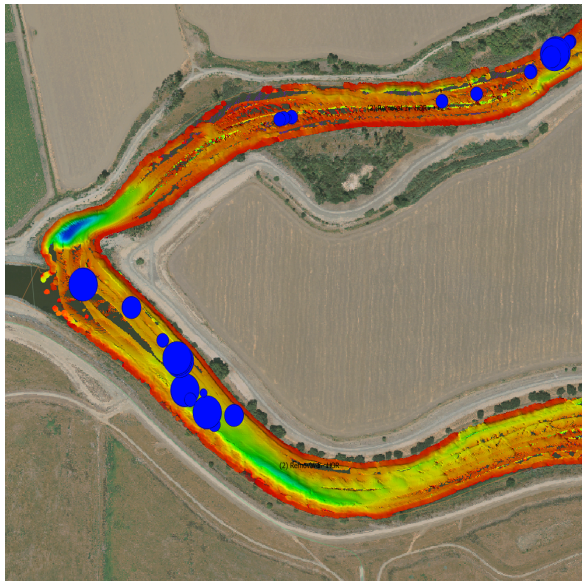
Largemouth bass

White catfish

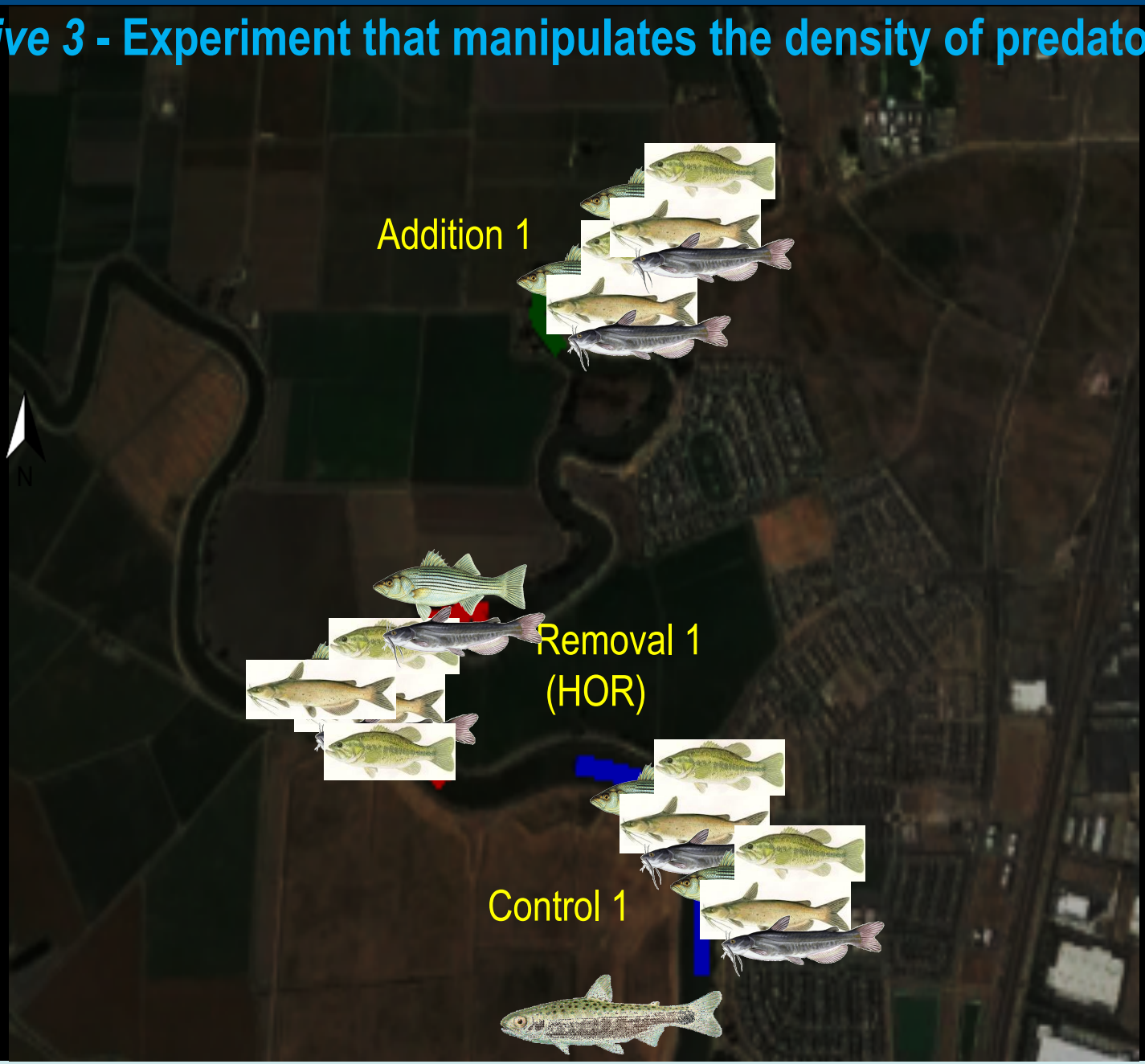
Channel catfish

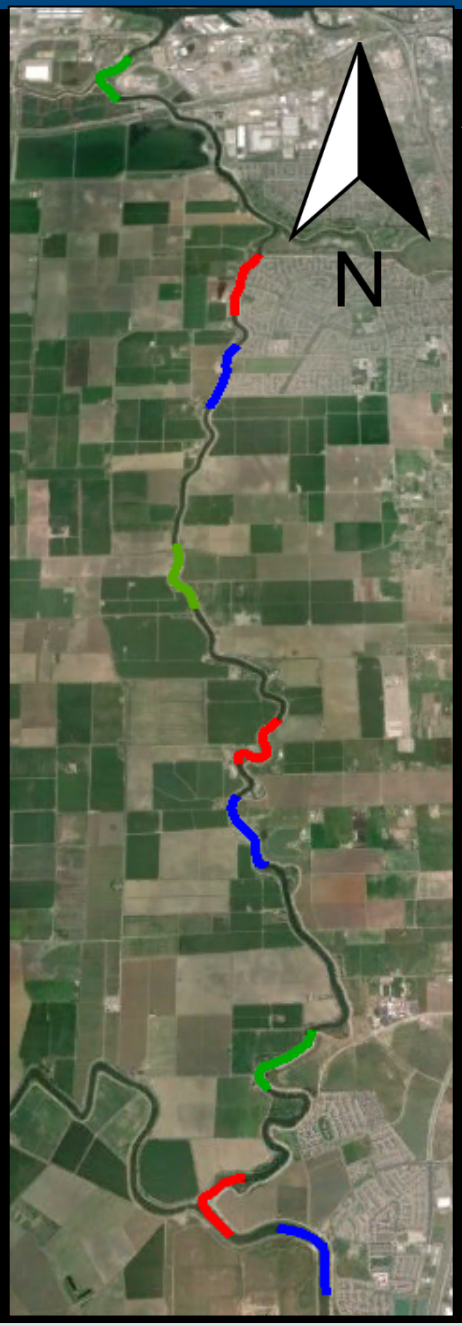
Objective 1 - Densities and local spatial distributions of predator fish

- Map river bathymetry, fishes, and flora with multi-frequency sonars and echosounders
- Track fish and estimate their lengths with multi-frequency backscatter
- Improve target detection with sample coherence
- Improve estimates of fish densities with high-resolution riverbed bathymetry
- Fish abundance appears to be patchy and variable with time
- Frequently repeated surveys needed to characterize fish behaviors and identify causes.



Objective 3 - Experiment that manipulates the density of predators





Downstream

Upstream

1 km

A3	Addition 3
R3	Removal 3
C3	Control 3
A2	Addition 2
R2	Removal 2
C2	Control 2
A1	Addition 1
R1	Removal 1 - HOR
C1	Control 1

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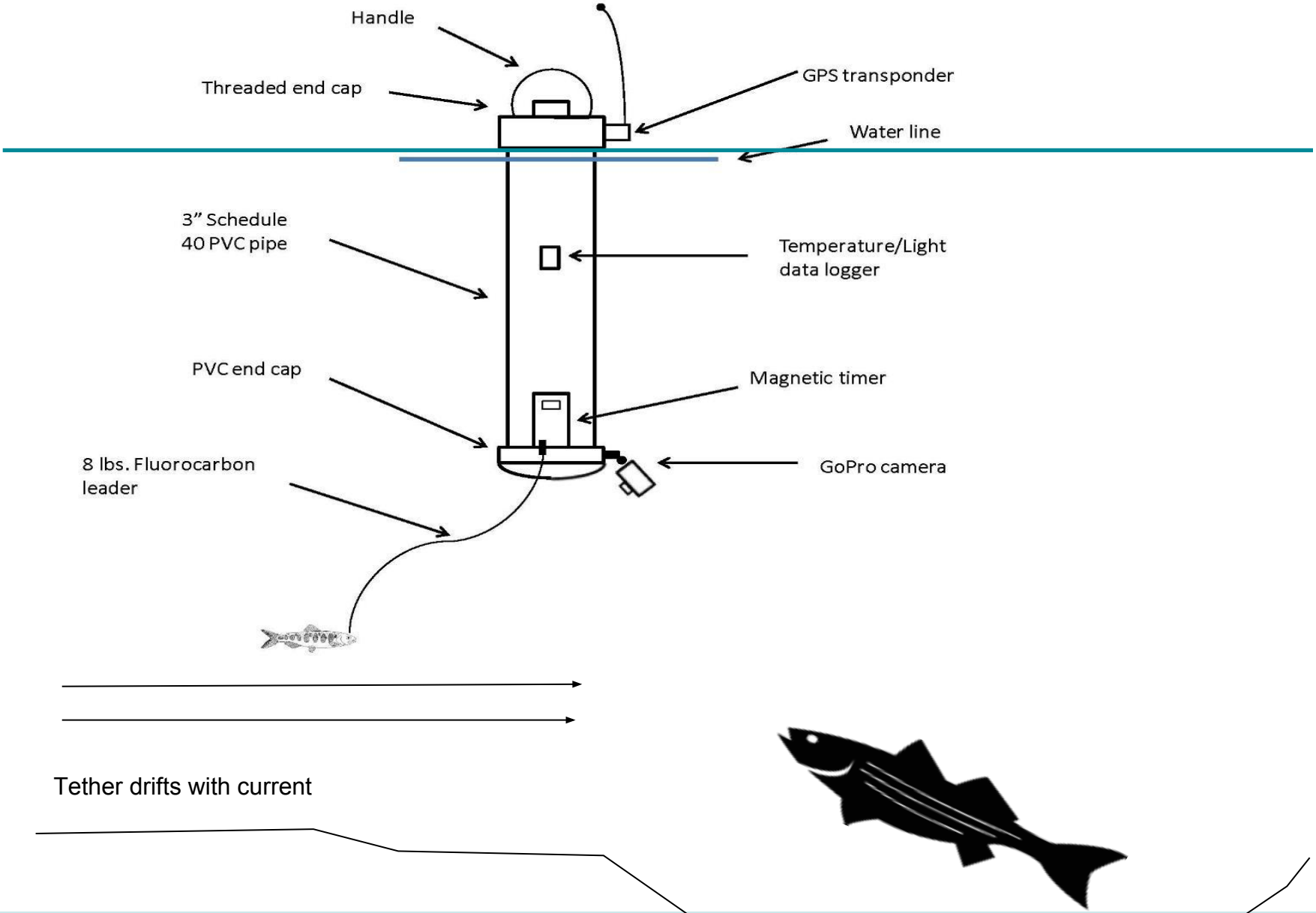
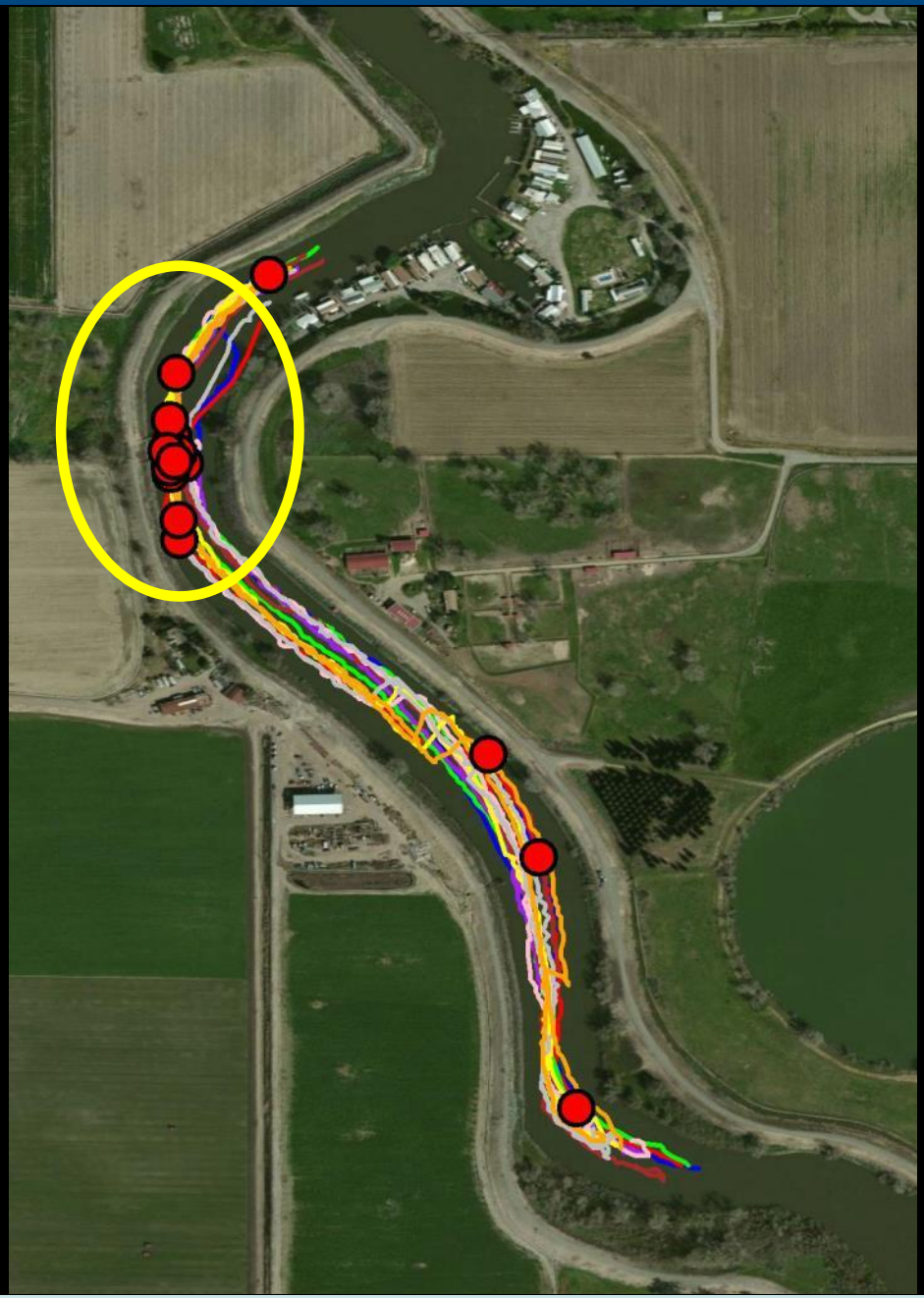
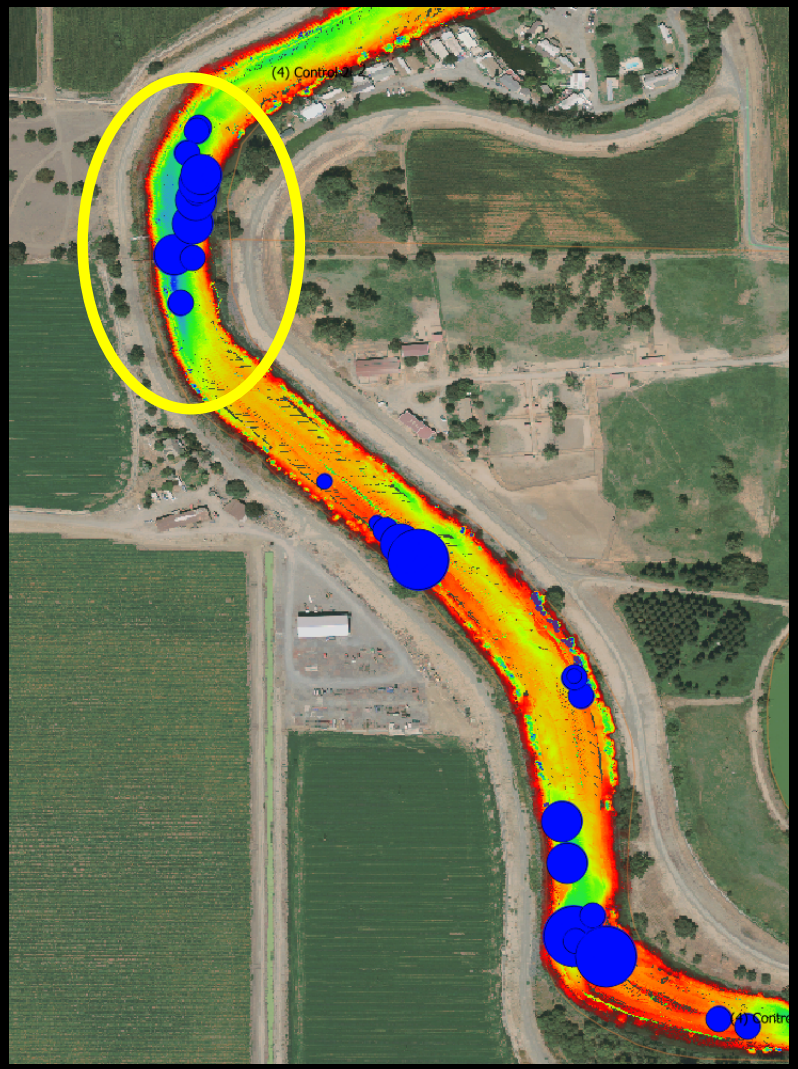
Objective 4 - Determine how predation on salmon smolts influenced by environment



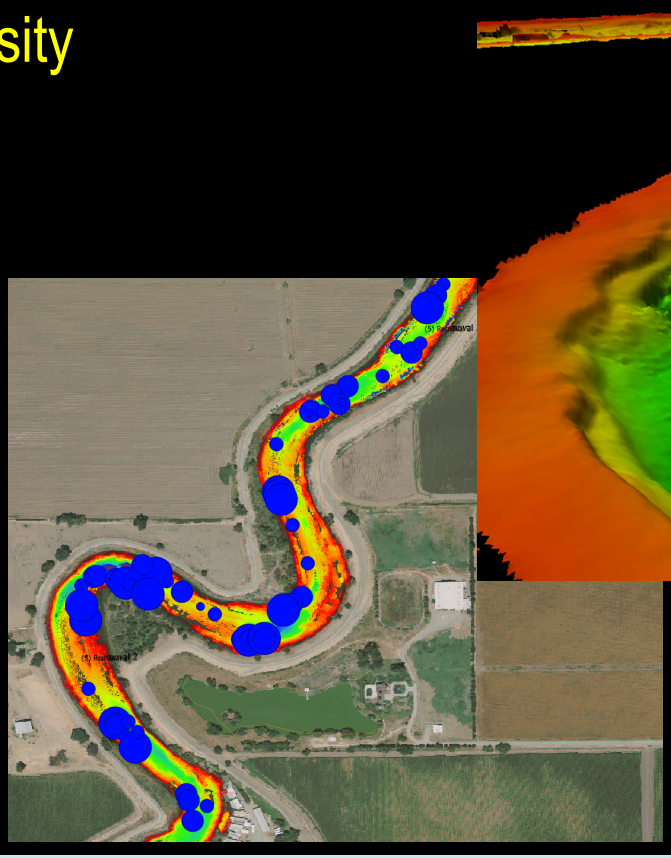


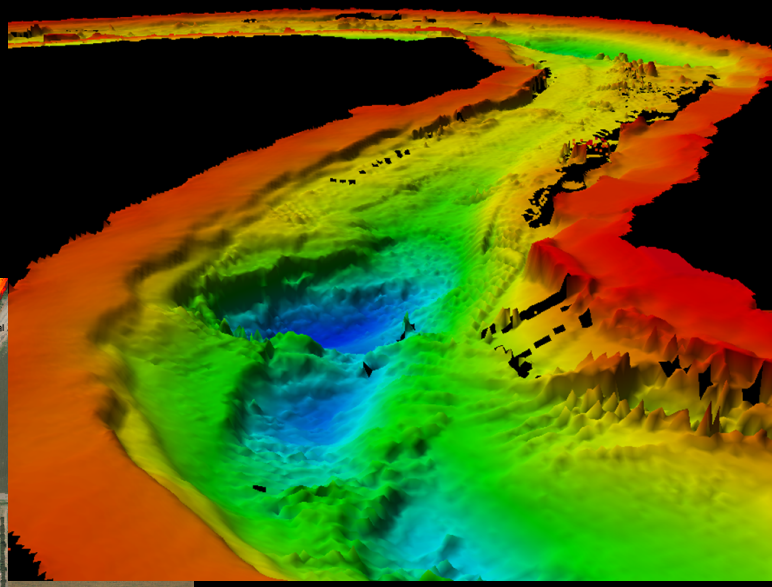

(4) Control

Objective 4 - Determine how predation on salmon smolts influenced by environment

- Habitat features- sinuosity, depth, channel location
- Temperature/ Dissolved oxygen
- Water velocity/direction (tide, pumping and flow)
- Prey transit time (as influenced by water velocity above)
- Turbidity/Light intensity
- Predator density
- Diel period

Model selection





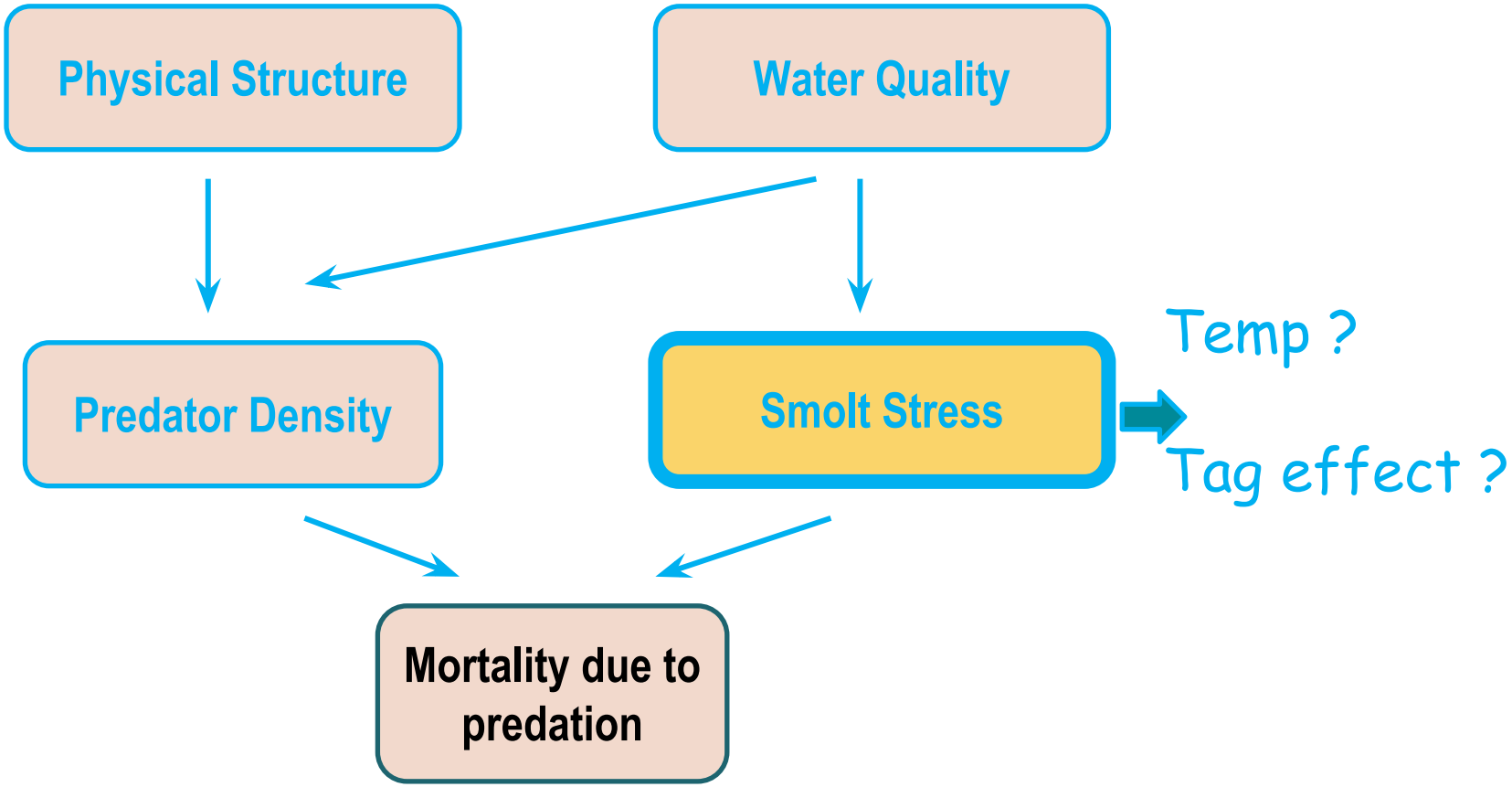
What if its not just predation?

Temperature (°C)

???

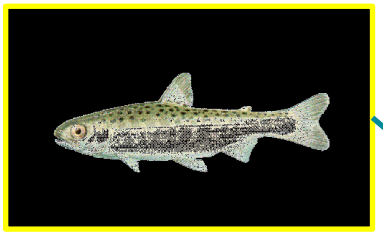
Date

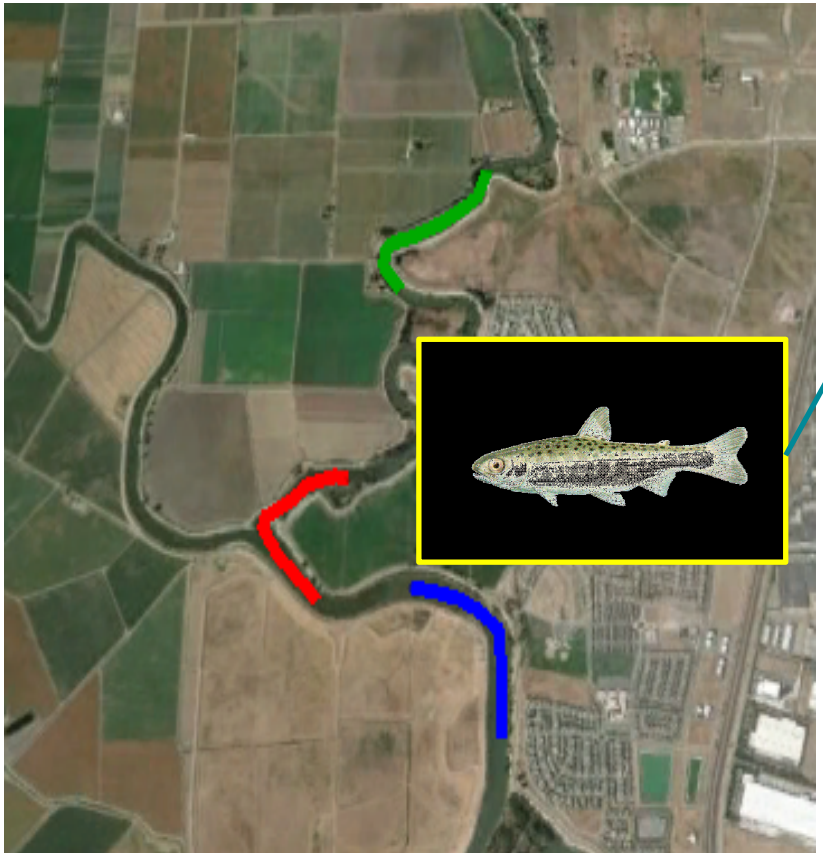
Physiology ?

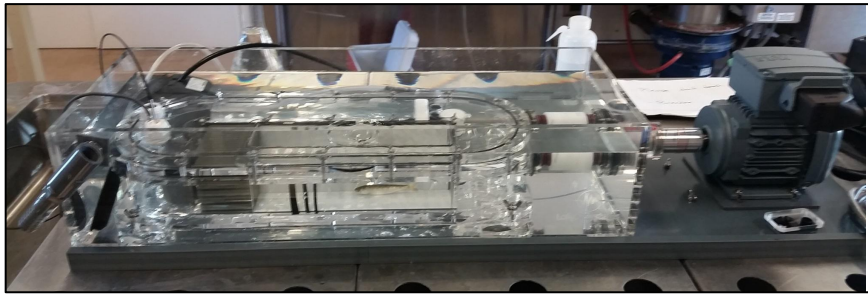

Physical Structure
Water Quality
Predator Density
Smolt Stress
Temp ?
Tag effect ?
Mortality due to predation

Comparative Survival/Swim Capacity

Hatchery





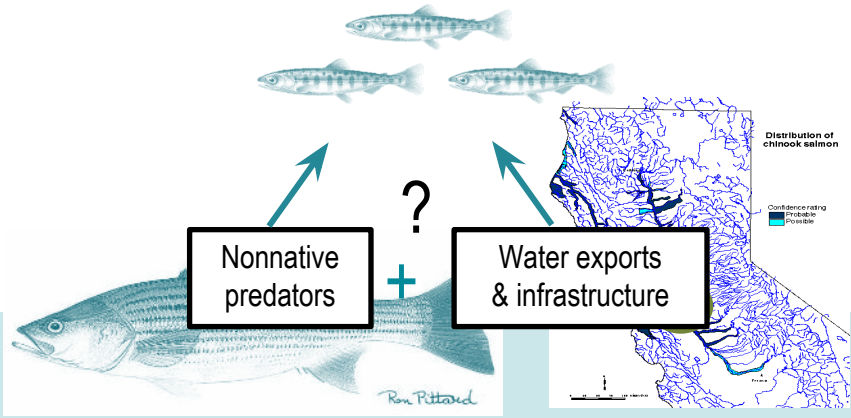


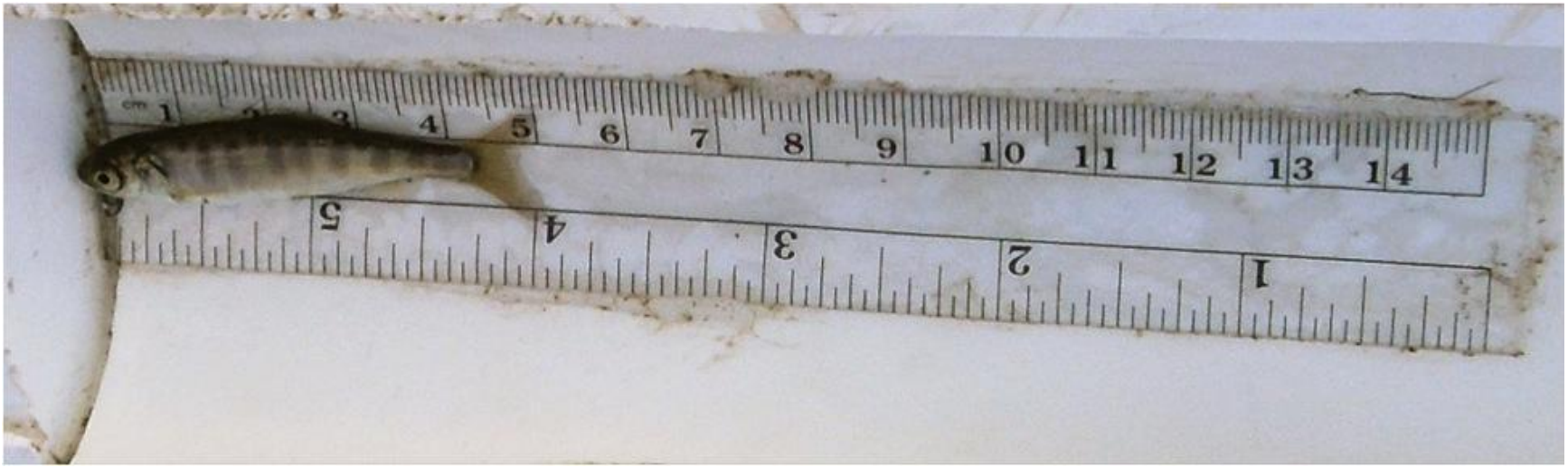
Final Thoughts…..

- Project stability challenged by soft $ and 80% contractor load
- Problem remains complex- not just Bass….
  - altered habitat, water diversions, and predators.
- Basin scale predator control?
  - Likely majority of mortality in small % of habitat
  - Model selection process should identify/predict

Proceed with mixture of habitat modifications and predator control

Balancing Fish + Agriculture + Human safety






5x the weight in 6 weeks

TNC and Drew Kelly

TNC

Funded by

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